Contract-Intensive International Trade*

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Abstract

Relation-specific transactions are growing in international trade. It remains unclear how such transactions respond to external shocks differently from ordinary non-relation-specific international transactions, since their contract details are rarely available to researchers. We combine three widely known data sources to tackle this question. We find that shocks are primarily absorbed by the price margin of relation-specific transactions, and by both price and quantity margins of non-relation-specific transactions. The difference in the adjusted margins also results in different passthrough patterns.

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1 Introduction

International trade is becoming contract-intensive. A large portion of cross-border transactions are between suppliers and clients, where the former make products specifically for the latter. Such relation-specific transactions, known as subcontracting, outsourcing, or offshoring, are different from ordinary international transactions where sellers and buyers gather in a world market and let a uniform market price equate supply and demand. A natural question arises: do such relation-specific transactions handle external shocks differently? This question is challenging to answer because the contract details involved in such transactions are huge in number, sophisticated in contents, and confidential in details.

This paper endeavors to answer this question using three widely known datasets. Suppliers in this paper refer to Chinese exporters. (1) Chinese Customs categorizes its exports into two types: relation-specific (processing trade) and non-relation-specific (ordinary trade).[1] (2) Using the US input-output tables, Nunn (2007) compiles a product-level measure of the relation-specific input intensity in production. (3) The bilateral exchange rate fluctuations between China and different foreign countries provide exemplary shocks that force the demand and supply sides to adjust their transactions. We examine how the relation-specific input intensity in foreign production (dataset (2)) and the bilateral exchange rate fluctuations (dataset (3)) interact to determine the price and quantity adjustments made by Chinese exporters under both export types (in dataset (1)).

Our empirical results show that, in response to exchange-rate fluctuations, firms adjust the (yuan) price margins of relation-specific exports, but by a smaller magnitude if their exports are used more intensively as inputs in foreign production. In comparison, firms adjust both price and quantity margins of non-relation-specific exports. The quantity adjustment is smaller in magnitude if their non-relation-specific exports are used more intensively as inputs in foreign production, whereas the price adjustment is invariant to that.

The above patterns, although initially puzzling, can be explained by incomplete contracting combined with incomplete exchange-rate passthrough. Think of a foreign-made final product whose production uses both relation-specific and non-relation-specific inputs, either one located in China and the other in its own country. When China's currency depreciates, the input made in China substitutes the other input at the margin, thereby raising the demand for the Chinese input. If the Chinese input is the relation-specific one, the raised demand elevates price but not quantity, because relation-specific inputs are unavailable on the spot market. If the Chinese input is the non-relation-specific one, the raised demand elevates both price and quantity, just as in a textbook partial equilibrium model.

Then the varying magnitudes of adjustments are easy to understand. An intensively used

[1] For background information on processing trade, see Feenstra and Hanson (2005) and Feenstra (2011). For other recent studies using this dataset, see Khandelwal, Schott and Wei (2013), Li, Ma, and Xu (2015), Manova and Zhang (2012), and Manova and Yu (2016).

input has a less elastic demand, which is a well-established fact in the literature on exchange-rate passthrough.[2] If the Chinese input is the relation-specific one, only the price margin is adjusted, such that a less elastic demand translates to a larger price adjustment, and thus a smaller yuan-price adjustment (i.e. less passthrough). If the Chinese input is the non-relation-specific one, the quantity margin is adjusted, and as expected, less so if this input is more intensively used. Here, the price margin is also adjusted, which reflects exchange-rate passthrough into the production cost and thus is unrelated to how intensively the input is used.

Of course, many Chinese exports are not inputs for foreign production but instead are goods for foreign consumption. We cannot make this distinction in the data, but the existence of goods for foreign consumption only works against finding statistically significant empirical results related to the production-based Nunn's measure (i.e. the previous dataset (2)). We also conduct various checks to confirm that the distinct adjustment patterns between the two types of exports are not driven by other factors.

This study contributes to the literature on incomplete contracting in international trade. This literature focuses on alleviating the contract incompleteness in an international context, including improving contract-enforcing institutions (Nunn 2007; Levchenko, 2007), improving ownership structures (Antràs, 2003; Antràs and Helpman, 2004; Feenstra and Hanson, 2005; Nunn and Trefler, 2008, 2013; Yeaple, 2006), and improving trade policies to correct input and output incentives (Antràs and Staiger, 2012a, 2012b). Departing from this literature, our study is not about alleviating contract incompleteness. All firms in our study are located in China. They have ownership of their inputs and outputs, and all their export transactions are undertaken at arm's length. What interests us is how differently price and quantity adjust, and how the differences relate to the relation-specific input intensity in production. Price and quantity, as the two constitutional dimensions of any economic transaction, offer a unique perspective on the impacts of contract incompleteness.

Our paper is also related to the growing number of studies that estimate exchange-rate passthrough using micro-level data, such as Amiti, Itskhoki, and Konings (2014), Berman, Martin, and Mayer (2012), and Hellerstein and Villas-Boas (2010). Among these studies, Hellerstein and Villas-Boas (2010) is the most relevant. They look into the producers who import inputs, and the exchange-rate passthrough in their study occurs to the prices of the final products. Different from their study, we examine the suppliers who export inputs to serve foreign producers, and the exchange-rate passthrough in our study occurs to the prices of the inputs. In particular, we differentiate two types of inputs, namely relation-specific inputs as opposed to non-relation-specific ones.

The rest of the paper is organized as follows. In Section 2, we derive hypotheses from a simple theoretical framework. In Section 3, we describe our empirical specifications and data. In Section

[2] See for example, Alessandria (2004), Atkeson and Burstein (2008), Auer and Schoenle (2016), Feenstra, Gagnon, and Knetter (1996), and Garetto (2012).

4, we report our empirical results. In Section 5, we conclude.

2 Theoretical Framework

In this section, we present a simple theoretical model to guide our later empirical study. The idea of the model is as follows. Foreign (i.e. outside of China) producers use two types of inputs: type-x inputs are relation-specific, each made by a specific supplier, while type-o inputs are non-relation-specific, each made by a supplier on the world market. Either of the two can be made in China. We observe the Chinese side of the model; that is, a Chinese supplier makes either a type-x input, or a type-o input. By assumption, the type of input not made by the Chinese supplier is made in the foreign producer's country (otherwise, exchange rate would not matter). Exchange-rate fluctuations cause a substitution between the two inputs towards the one whose corresponding currency depreciates relative to the other.

The relation-specific (type-x) inputs are made in batches such that an exchange-rate change does not alter the ordered quantity, but the two sides have to find a way to adjust the value of the order in response to the exchange-rate change. This results in a change in the unit value, which is isomorphic to a price change. In contrast, the non-relation-specific (type-o) inputs are made in real time, so that an exchange-rate change alters both trading price and trading quantity. These differences in price and quantity behaviors between the two types of inputs will be summarized as two testable hypotheses.

2.1 Setup

Consider the foreign production of product j using the technology represented by

$$y_j = \left[\phi_j x_j^{(\zeta_j - 1)/\zeta_j} + (1-\phi_j) o_j^{(\zeta_j - 1)/\zeta_j}\right]^{\zeta_j/(\zeta_j - 1)}, \tag{1}$$

where x_j (respectively, o_j) is the quantity of the relation-specific (respectively, non-relation-specific) input, ϕ_j is the intensity of input-x usage (known as the relation-specificity of product j), and $\zeta_j > 1$ is the elasticity of substitution. Denote the price of x_j by p_j and that of o_j by q_j, both denominated by the foreign currency. Then the input demand functions follow:

$$x_j = p_j^{-\zeta_j} \phi_j^{\zeta_j} C_j^{\zeta_j} y_j, \quad o_{ij} = q_i^{-\zeta_j} (1-\phi_j)^{\zeta_j} C_j^{\zeta_j} y_j, \tag{2}$$

where C_j is a collection of parameters that represents the unit cost level in the foreign production of product j:

$$C_j \equiv \left[\phi_j^{\zeta_j} p_j^{1-\zeta_j} + (1-\phi_j)^{\zeta_j} q_j^{1-\zeta_j}\right]^{1/(1-\zeta_j)}. \tag{3}$$

A Chinese supplier makes either input x_j or input o_j but not both, and the other input is made in the foreign producer's country (otherwise the exchange rate between the two countries does not matter). The Chinese supplier uses local and foreign factors, along with technologies represented by the following Cobb-Douglas unit-cost function:

$$c_j^m = \left(w_{CN}^m/E\right)^{\beta_j}\left(w_{FN}^m\right)^{1-\beta_j}, \tag{4}$$

where $m \in \{x, o\}$ is the input type and w_{CN}^m (respectively, w_{FN}^m) denotes the price of the Chinese (foreign) factor used in making the input. w_{CN}^m and w_{FN}^m are denominated by the foreign currency (just as the previous p_j and q_j). E is the real exchange rate, denoting E yuan (the unit of Chinese currency) per unit of the foreign currency.[3] The parameter $0 < \beta_j \leq 1$ represents the share of Chinese factors in use. Equation (4) implies that, from the foreign producer's perspective, if the yuan depreciates (appreciates), E rises (declines) such that the unit cost decreases (increases).

We need two "dates" to introduce an exchange rate change, as well as two "dates" to model the relation-specificity of input x_j. By consolidating the four "dates" into two, we specify the following sequence of events:

Date 1 Exchange rate is E^*; x_j is made but not traded.

Date 2 Exchange rate is $E = E^* + e$, where e is a zero-mean random variable that realizes on date 2; o_j is made; both x_j and o_j are traded and used in foreign production.

We intentionally let x_j be made on a date prior to the date when it is traded. This setup differentiates *ex ante* decisions from *ex post* decisions, serving as the foundation of modeling relation-specificity. In contrast, o_j should be made and traded on the same date (date 2), because making it on date 1 according to the old exchange rate is strictly dominated by making it on date 2 according to the new exchange rate.

Two notes on x-suppliers should be made at this point. First, the input quantity x_j, which is decided on date 1, is based on the date-1 exchange rate E^* and the expectation (zero) of the date-2 exchange-rate shock e. It is unaffected by the realization of e. Chinese exporters are in perfect competition on date 1, expecting to receive the unit cost payment on date 2 for each unit of their outputs. Second, on date 2, if e turns out to be zero, then the trading of the input stock x_j occurs as expected. If e turns out to be non-zero, the two sides use Nash bargaining to divide the cost change caused by the new exchange rate.[4] Notice that on date 2, with the input stock x_j given, the Chinese supplier becomes a monopoly for the foreign producer while the foreign producer becomes a monopsony for the Chinese supplier, such that there does not exist a conventional price mechanism to revalue the stock x_j. For simplicity, we assume equal bargaining powers on

[3]All exchange rates in this paper refer to real exchange rates, since the driving forces here are the time-varying differences in relative factor costs between China and foreign countries.

[4]This is slightly different from the Nash bargaining in Antràs and Helpman (2004). They let the two sides bargain on the entire value, whereas we let them bargain on the change of value. When they bargain on the entire value, the exchange-rate passthrough would be unrelated to ϕ_j.

the two sides, which entitle each side a half of the cost change.[5]

Unlike x-suppliers, o-suppliers are constantly in perfect competition. Their prices, set on date 2 according to the new exchange rate, are equal to their unit costs in equation (4). We now formally move on to derive the price and quantity behaviors under each input type.

2.2 Trading Price and Quantity

Type-o Inputs We start with type-o inputs, which involve incomplete passthrough but not incomplete contracting. By equation (4), the change in exchange rate will pass into the trading price at the rate of β_j. Intuitively, a depreciation (appreciation) of the yuan reduces (raises) the unit cost and thus the price. The more the local (Chinese) factor is used, the more the price changes.

For easy connection with the data, we formulate price-related hypotheses using yuan denomination. Here, equation (4) implies

$$q_j^{yuan} \equiv Eq_j = E^{1-\beta_j}\left(w_{CN}^o\right)^{\beta_j}\left(w_{FN}^o\right)^{1-\beta_j},$$

and thus the price elasticity equals

$$\frac{d\ln q_j^{yuan}}{d\ln E} = 1-\beta_j > 0. \tag{5}$$

Turning to the quantity, we obtain the quantity elasticity from equation (2):

$$\frac{d\ln o_j}{d\ln E} = \beta_j\zeta_j(1-S^o(\phi_j)) > 0, \tag{6}$$

where

$$S^o(\phi_j) \equiv \frac{(1-\phi_j)^{\zeta_j} q_j^{1-\zeta_j}}{\phi_j^{\zeta_j} p_j^{1-\zeta_j} + (1-\phi_j)^{\zeta_j} q_j^{1-\zeta_j}}, \tag{7}$$

is decreasing in ϕ_j. Remember that when we are concerned with o_j, its corresponding x_j is made abroad. That is, a depreciation (appreciation) of the yuan will raise the trading quantity o_j because the cheaper Chinese o_j substitutes the foreign x_j at the margin. The magnitude of the substitution is decreasing in the o-intensity measured by $1-\phi_j$, because an intensive initial use of o_j limits the potential for quantity change. In other words, the magnitude of change is increasing in the x-intensity ϕ_j, known as "relation-specificity" and later measured by Nunn's measure.

To summarize, without loss of generality, take the depreciation of the yuan:

Hypothesis 1 *For type-o inputs, a depreciation of the yuan*

[5] Assigning unequal bargaining powers would not make any qualitative difference. That would give the side with more bargaining power a more favorable position when its currency depreciates. The resulting difference is only in the magnitude which would then be contingent on the direction of the exchange-rate change.

(a) raises trading prices (in yuan), with an elasticity unrelated to ϕ_j, and

(b) raises trading quantities, with an elasticity rising in ϕ_j.

Type-x Inputs We now turn to type-x inputs, which involve both incomplete passthrough and incomplete contracting. Their trading prices depend on (i) the the new exchange rate E and (ii) their existing stocks produced according to the old exchange rate E^*. Recall equation (4), which gives the unit cost at the old exchange rate E^*:

$$c_j^{x*} = (w_{CN}^x/E^*)^{\beta_j}(w_{FN}^x)^{1-\beta_j}. \tag{8}$$

The resulting output is, according to equation (2),

$$x_j^* = \left(c_j^{*x}\right)^{-\zeta_j} \phi_j^{\zeta_j} \left(C_j^*\right)^{\zeta_j} y_j, \tag{9}$$

where C_j^* is also based on the old exchange rate E^*.

If we treat equation (9) as a function and find its inverse function, we can get the current unit value of any quantity x_j:

$$v_j = \left(x_j\right)^{-\frac{1}{\zeta_j}} \phi_j C_j y^{\frac{1}{\zeta_j}}, \tag{10}$$

where C_j is based on a general exchange rate E. In fact, if the E coincides with the old exchange rate E^* and $x_j = x_j^*$, v_j would be equal to c_j^{x*}:

$$v_j\big|_{x_j=x_j^*,E=E^*} = \left(x_j^*\right)^{-\frac{1}{\zeta_j}} \phi_j C_j^* y^{\frac{1}{\zeta_j}} = c_j^{x*}. \tag{11}$$

Here, $x_j = x_j^*$ refers to the fact that v_j is a revaluation of each unit of the existing stock x_j^*. Generally speaking, the new exchange rate E is different from the old exchange rate E^*, so that

$$v_j\big|_{x_j=x_j^*} = \left(x_j^*\right)^{-\frac{1}{\zeta_j}} \phi_j C_j y^{\frac{1}{\zeta_j}}, \tag{12}$$

which is a function whose value depends on E. Intuitively, a depreciation of the yuan will raise the demand for the Chinese-made x_j, making C_j more dependent on p_j and thus increasing the unit value of the existing stock x_j^*. Similarly, an appreciation of the yuan will decrease the unit value of x_j^*. In short, E is an input demand shifter that affects the unit value of the existing stock through its relative weight within the foreign producer's cost structure.

Given $E \neq E^*$, the Chinese supplier and foreign producer engage in a Nash bargaining to split the change in unit value. Given equal bargaining powers between the two sides, equation (12) implies the following trading-value elasticity:

$$\frac{d\ln v_j\big|_{x_j=x_j^*}}{d\ln E} = -\frac{\beta_j}{2} S^x(\phi_j), \tag{13}$$

where

$$S^x(\phi_j) \equiv= \frac{\phi_j^{\zeta_j} p_j^{1-\zeta_j}}{\phi_j^{\zeta_j} p_j^{1-\zeta_j} + (1-\phi_j)^{\zeta_j} q_j^{1-\zeta_j}}, \tag{14}$$

is increasing in ϕ_j. The $S^x(\phi_j)$ in equation (13) comes from $d\ln C_j/d\ln E = -\beta_j S^x(\phi_j)$ and the one half comes from the equal splitting of the cost change. Intuitively, it is known to both sides that the stock x_j^* is now valued differently than before. Take a one percent depreciation of the yuan for example. Now, the Chinese supplier and the foreign producer split the $-\beta_j S^x(\phi_j)$ percent of the unit value change in half. The foreign producer purchases it with $\beta_j S^x(\phi_j)/2$ percent less payment per unit.

Notice that the unit value is isomorphic to price. So, we can rewrite (13) as $d\ln p_j/d\ln E = -\beta_j S^x(\phi_j)/2$. To keep consistency with the price part of Hypothesis 1, we also use the yuan to denominate it. Then we have

$$\frac{d\ln p_j^{yuan}}{d\ln E} = 1 - \frac{\beta_j}{2} S^x(\phi_j), \tag{15}$$

Remember that $S^x(\phi_j)$ is increasing in ϕ_j, such that this price elasticity is decreasing in $S^x(\phi_j)$. Intuitively, an intensive initial use of x_j enlarges the potential for price change, translating to a smaller passthrough rate and thus less yuan-price change.

To summarize, take the depreciation of the yuan as before:

Hypothesis 2 *For type-x inputs, a depreciation of the yuan*

(a) raises trading prices (in yuan), with an elasticity declining in ϕ_j, and

(b) does not affect trading quantities.

Remarks The above model is purposefully kept simple to deliver clear hypotheses. It connects exchange-rate fluctuations with the x-versus-o substitution in foreign production. It abstracts away from other consequences of exchange-rate fluctuations. For example, we did not consider how y_j, namely the quantity of final product j sold on the foreign market, responds to exchange-rate fluctuations. In other words, the above model is concerned with a cost-minimization problem for foreign producers with y_j given. Analyzing the change in y_j would necessitate knowing the demand function for the final product j in the foreign country. In theory, the yuan's depreciation, through the production-cost savings analyzed above, tends to lower the price charged by foreign producers on their local consumers, and raise the quantity demanded by foreign consumers. This could be a channel through which exchange-rate fluctuations indirectly affect the prices and quantities of inputs x and o.

We are unable to assess this indirect channel without knowing or assuming the foreign consumers' demand function for the final products. Nevertheless, one thing about that indirect channel is clear — it would only make adjustment patterns more similar between the two types of inputs. Through the channel of y_j, exchange-rate fluctuations could only affect inputs x_j and o_j in a non-discriminatory way. Thus, this potential channel works only against finding empirical differences in adjustment patterns between the two types of inputs. Given that we later find different adjustment patterns empirically, this indirect channel is not an important concern. In other words, the between-type differences in price and quantity adjustments are at worst understated (rather than overstated).

Also, in the above model, we consider a foreign producer that purchases inputs from China rather than a foreign consumer who purchases consumption goods from China. Theoretically, a producer's cost minimization problem and a consumer's utility maximization have little difference from each other. We choose the producer's problem because by doing so, we match the x-intensity in the theoretical production with the production-based relation-specificity measure constructed by Nunn (2004). Some Chinese exports are consumption goods rather than inputs. We cannot tell them apart in the data, but the potential existence of consumption goods in the data only works against finding statistically significant results related to the production-based Nunn's measure.

3 Empirical Specifications and Data

3.1 Empirical Specifications

We now specify estimating equations for testing Hypotheses 1 and 2. The Chinese Customs records Chinese exports under two categories, processing trade (corresponding to input x) and ordinary trade (corresponding to input o). Under each type, we observe in the data the Chinese exporters (indexed by i), the corresponding products (indexed by j), and the destination country (indexed by d). We cannot observe their foreign buyers, and thus we conceptually apply the above model to the relation between Chinese exporter i and its "aggregated buyer" in each product-destination (jd) duplet. That is, observing a triplet ijd implies that Chinese exporter i has at least one buyer in product j's market in destination country d. The destination country (d) dimension also brings in the variations in exchange rates across countries. Generally, our regressions take the form

$$DEP_{ijd} = \lambda \ln E_d + \delta \ln E_d \times \phi_r + \bar{\gamma}' \Omega_{ijd} + \epsilon_{ijd}, \tag{16}$$

where the dependent variable DEP_{ijd} could be either log yuan price or log quantity, Ω_{ird} is a collection of exporter, product, and destination characteristics that serve as control variables, and ϵ_{ijd} is the error term. Here, we suppress the time dimension (year index t) for convenience.

Regression (16) will be run for type-x and type-o inputs separately, and we are interested in the estimated coefficients $\hat{\lambda}$ and $\hat{\delta}$. Specifically, our previous hypotheses now translate to:

Hypothesis 1 Regarding ordinary-trade exports (the non-relation-specific type-o inputs):

(a) $(\hat{\lambda} > 0, \hat{\delta} = 0)$ for price;

(b) $(\hat{\lambda} > 0, \hat{\delta} > 0)$ for quantity.

Hypothesis 2 Regarding processing-trade exports (the relation-specific type-x inputs):

(a) $(\hat{\lambda} > 0, \hat{\delta} < 0)$ for price;

(b) $(\hat{\lambda} = 0, \hat{\delta} = 0)$ for quantity.

3.2 Data

Our primary data source is Chinese Customs. Chinese Customs records the universe of export transactions conducted by every Chinese firm towards every destination, with product codes (Harmonized-System Codes) and transaction types. The transaction types include processing trade and ordinary trade, which correspond to the previous type-x and type-o, respectively. In the statistical system of Chinese Customs, processing trade refers to the sales of products made for specific foreign producers, while ordinary trade to the sales of products through the world market not for specific foreign producers. Under both types, each transaction contains F.O.B. value and quantity. The original F.O.B. values are originally in the US dollar, and we convert them into Chinese yuan. We use the yuan value and quantity to compute yuan price at the firm-product-destination-year level.

In this study, we limit exporters to private-owned (i.e. not state-owned) firms.[6] We do not consider state-owned or mixed ownership types (including joint venture and collective ownership), since they may have different pricing and inventory behaviors. In an average year, private-owned exporters account for 32.1% of the observations. We also require that exporters own all their production factors, whether they purchase them domestically or abroad. This ensures that they are able to make independent price and quantity decisions.

We match the above data with macroeconomic data according to their country-year (dt) duplets. Macroeconomic data, including real exchange rates, real GDP, and producer price indices (PPI), are obtained from the Thomson Reuters Datastream Professional.[7] The yuan was pegged to the US dollar until July 2005. We limit our sample to the years 2000 to 2005. In **Figure 1**, we first plot the yuan's exchange rates against the US dollar; then, we plot the exchange rates of China's

[6] The six ownership types in China's statistical system are state-owned, Sino-foreign contractual joint venture, Sino-foreign equity joint venture, foreign-owned, collective-owned, and private-owned.

[7] Monthly bilateral exchange rates between the US dollar and other currencies are the spot rates on the 13th of each month. The exchange rate observed and used by exporters is normally earlier than that of the recorded sales. This time gap was noted in Goldstein and Khan (1985) as an important characteristic of international transactions. Accounting for it by using a lagged exchange rate is a common practice in the literature (see, e.g. Campa and Goldberg (2005)). In our context, the usual time gap between placing an order and shipping goods abroad is approximately three months. We lag three months when constructing exchange rates; specifically, we take the average of monthly exchange rates between October of the previous year and September of the current year.

major trade partners against the US dollar. As shown, the yuan-US dollar exchange rate was close to constant during the sample period, while the US dollar was overall depreciating against those seven currencies late in this period. This setting strengthens our identification because the variations in bilateral exchange rates were exogenous to both countries. That is, the Chinese government could not subsidize its products exported to a destination country by depreciating the yuan against that country's currency. Neither could the destination country's government manipulate its exchange rate against the yuan — unless it manipulates its exchange rate against the US dollar, which would have substantial macroeconomic consequences. Since the yuan was pegged to the US dollar during the sample period, the useful variations in the yuan-dollar real exchange rate have to be from the relative price levels of the two countries, which were stable during the time of our sample.[8] Given the lack of variations, we have to exclude exports to the US, which account for one fifth of China's total exports.

Descriptive statistics are reported in the Appendix Table A1. In addition to trading values and prices, Panel A in the table summarizes the numbers of firms, products, destination countries, years, and their combinations. Panel B in the table summarizes the data on exchange rates, PPI and GDP. The real exchange rate refers to E yuan per unit of the corresponding foreign currency. Thus, a greater (smaller) E means that the yuan depreciates (appreciates). Since the levels of exchange rates are not comparable across countries (e.g. 1 US dollar equals approximately 1 Australian dollar but equals 30 Thai bahts), we report statistics on their rates of change instead of levels. Panel C summarizes the industrial data. Nunn's measure, as a measure of the relation-specificity ϕ, is based on the Rauch (1999) classifications.[9]

We now move on to the control variables Ω_{ijd} in regression (16). We cannot observe the elasticities of substitution ζ_j in the customs data, so we proxy for them using the corresponding estimates in Broda, Greenfield, and Weinstein (2006).[10] To control for the elements other than the relation-specificity ϕ_j in the cost-share variables (see equations (7) and (14)), we construct (i) every Chinese exporter's market share within the product-year duplet in China under the corresponding transaction type, and (ii) its market-share rank (the producer with the largest (smallest) market share has rank 0 (rank 1)). That is, conditional on the same ϕ_j and rank, an exporter that has a larger market share in China may have a greater $S^x(\phi_j)$ or $S^o(\phi_j)$ within its foreign client's cost structure.[11] Also, we cannot observe the product-level use of imported factors β_j in equation

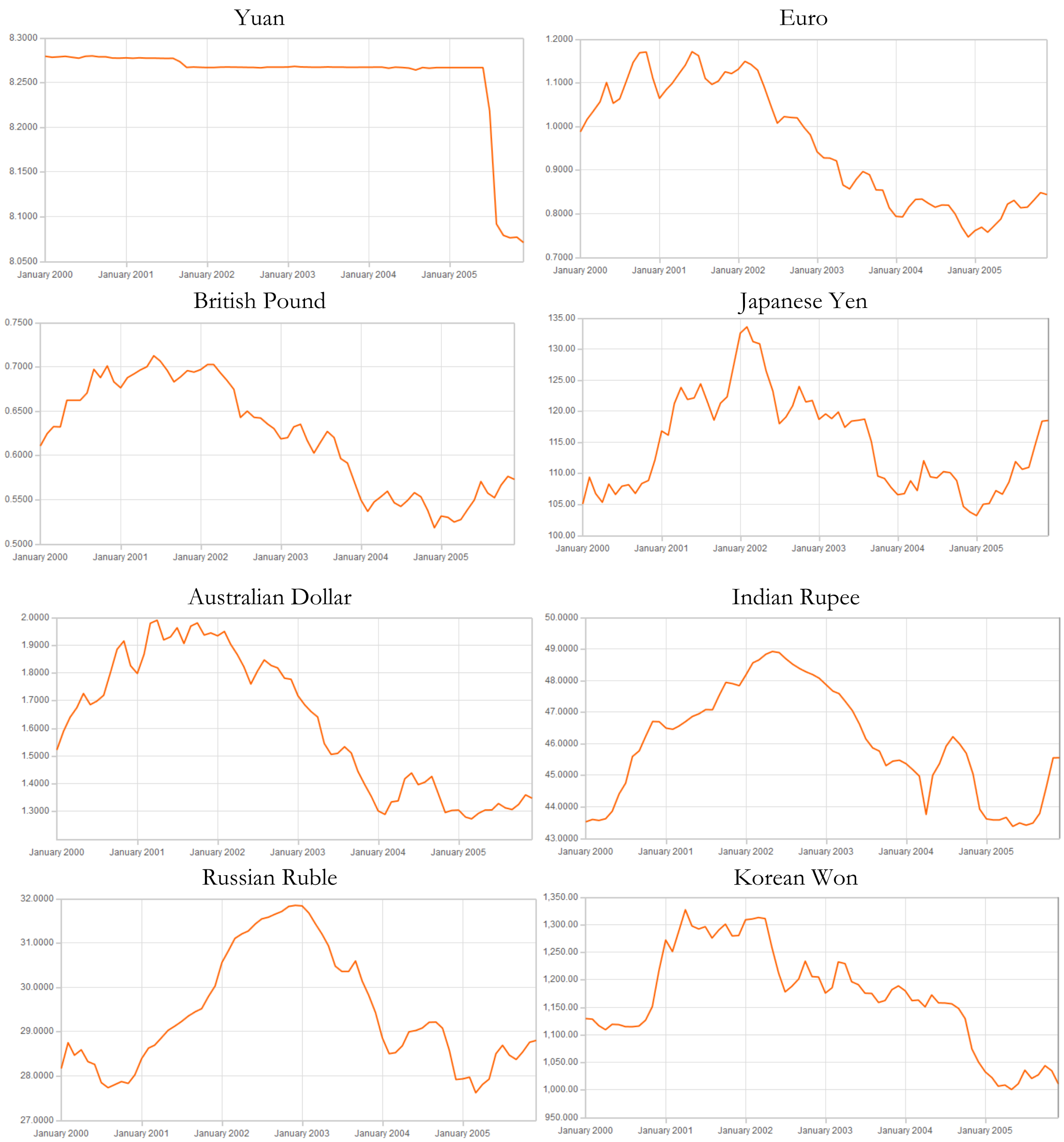
[8]Take the US price level as 100; China's price level rises from 39.2 in 2000 to 40.9 in 2005.

[9]Rauch (1999) categorizes products into "traded on organized exchanges," "reference priced," or "neither." In Rauch (1999) and Nunn (2007), the first and third classes are considered as homogenous goods and differentiated goods, respectively. The second class, reference priced products, can be counted into either group. With input-output tables, Nunn first identified what inputs are used to produce each product and then computed the shares of inputs corresponding to the three Rauch classes. We use the Nunn measure that counts both "reference priced" and "neither" as relation-specific inputs. Also, Rauch (1999) has both liberal and conservative classifications, and Nunn (2007) correspondingly reports two measures. We use the Nunn measure based on the conservative classification. Using the liberal classification does not alter our findings.

[10]The data are available at http://www.columbia.edu/~dew35/TradeElasticities/TradeElasticities.html.

[11]For example, given $\phi = 0.5$, the best ranked exporter within a Chinese duplet, if having 10% rather than 2% of its Chinese market, should also account for a greater share within its client's cost structure.

Figure 1: Yuan, US Dollar, and Currencies of China's Major Trade Partners (US Dollar=1)



(8) and proxy for it using the product-level R&D intensities compiled by Kroszner, Laeven, and Klingebiel (2007).[12] The rationale behind this is that the inputs made in China, a developing country, tend to use more imported factors if they involve R&D intensively. Lastly, we control for GDP and producer price index (PPI), following the standard practice in the literature (e.g. Campa and Goldberg, 2005).

[12] They constructed the measure using the median level of the ratio of R&D expenses to sales for US firms in COMPUSTAT and used that as the R&D intensity measure for industries in 38 developed and developing countries.

4 Empirical Results

4.1 Main Findings

Since Hypothesis 1 closely follows the conventional wisdom, we start with testing Hypothesis 2. The previous regression (16) is run to test Hypothesis 2a, with its dependent variable being log yuan price. The most stringent supplier-product-destination (ijd) fixed effects, along with a year fixed effect, are used, which absorb all time-invariant non-interacted terms (such as ϕ_j). We cluster standard errors at the country-year level to account for potential correlation of the error term within country-year duplets.[13]

Table 1: Trading Price (Type x, Hypothesis 2a)

Dependent variable is ln(price)

	(1)	(2)	(3)	(4)
Ln(exchange rate) × relation specificity§	-1.275***	-1.190**	-1.166**	-1.165**
	[0.347]	[0.484]	[0.482]	[0.482]
Ln(exchange rate) × R&D intensity§		0.010*	0.009*	0.009*
		[0.006]	[0.006]	[0.006]
Ln(exchange rate) × elasticity of substitution§		-8.770*	-9.127*	-9.149*
		[5.177]	[5.205]	[5.209]
Ln(exchange rate)	0.957***	1.019***	1.027***	1.028***
	[0.222]	[0.294]	[0.293]	[0.293]
GDP		-0.198	-0.156	-0.153
		[0.215]	[0.215]	[0.213]
PPI		0.159	0.157	0.157
		[0.100]	[0.100]	[0.100]
Market share			0.045*	0.046*
			[0.023]	[0.023]
Ln(exchange rate) × market share			0.010	0.010
			[0.008]	[0.008]
Firm rank				0.010
				[0.008]
Ln(exchange rate) × firm rank				0.007
				[0.030]
Share of estimated λ+δ×relation specificity in [0,1]	90%	94%	99%	99%
Observations	48,399	36,512	36,512	36,512

Notes: Firm-product-country fixed effects and year fixed effects are included. Cluster-robust standard errors in brackets. Clustering is at the country-year level. § These three variables are included only as interaction terms because their own variations are absorbed by the fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

[13] This follows Berman, Martin, and Mayer (2012). Clustering the standard errors at the product-country level instead does not alter our findings (results are available upon request).

Hypothesis 2a contends that when the yuan depreciates (i.e. E rises), the yuan price will be higher, with an elasticity declining in relation-specificity. That is, $\hat{\lambda} > 0$ and $\hat{\delta} < 0$ in terms of regression (16). The results, as reported in **Table 1**, support the hypothesis. Column (1) includes no control variable, thereby having the largest sample size. The exchange rate shows a positive effect on the yuan price, the magnitude of which is smaller if relation-specificity is higher. In column (2), we control for GDP and PPI, as well as interactions of exchange rate with elasticity of substitution and R&D intensity, respectively. With these control variables included, $\hat{\lambda}$ and $\hat{\delta}$ remain positive and negative, respectively. We also control for market share in column (3) and further control for market-share rank in column (4). The results are similar to those in columns (1) and (2).

Since the relation-specificity measure ϕ ranges between 0.03 and 0.99, the marginal effect of exchange rate $\hat{\lambda} + \hat{\delta}\phi$ may fall outside [0,1]. Therefore, in all columns, we check the shares of observations with $\hat{\lambda} + \hat{\delta}\phi$ that fall within [0,1], which turn out to be mostly within the range, especially when control variables are included. In addition, using the estimates in column (4) of Table 1, we calculate the average passthrough rate of exchange rate, which is approximately 55%.

Turning to **Hypothesis 2b**, we run regression (16) with log quantity as the dependent variable. The results are reported in **Table 2**, the structure of which follows that of Table 1. It is clear that, as predicted, quantity does not respond to exchange-rate fluctuations.

Lastly, we test Hypothesis 1 using regression (16) and the customs data on ordinary trade. **Hypothesis 1a** contends that a depreciation of the yuan raises trading prices (in yuan), with an elasticity unrelated to ϕ_j, while **Hypothesis 1b** contends that a depreciation of the yuan raises the trading quantities, with an elasticity rising in ϕ_j. That is, in terms of regression (16), $\hat{\lambda} > 0$ and $\hat{\delta} = 0$ for price, while $\hat{\lambda} > 0$ and $\hat{\delta} > 0$ for quantity. The results are reported in **Table 3**, which follows the structure of Tables 1 and 2 but is more compactly displayed. The results are in line with Hypothesis 1.[14]

Before moving on to robustness checks, we graphically summarize in **Figure 2** how the impacts of exchange rates on different types of transactions correlate with relation-specificity. Specifically, we first estimate transaction adjustments in response to exchange-rate fluctuations by four-digit HS codes, then plot the estimates against relation-specificity for the price under type x (corresponding to Hypothesis 2a, displayed in the left panel) and for the quantity under type o (corresponding to Hypothesis 1b, displayed in the right panel). Dashed curves in both panels are quadratic predictions that highlight the patterns.

[14] We also find that all else held equal, the standard deviation of price is smaller by 9 percent under type o than under type x. This is in line with our expectation, since non-relation-specific trading is supposed to have more homogeneous prices across the market.

Table 2: Trading Quantity (Type x, Hypothesis 2b)

Dependent variable is ln(quantity).

	(1)	(2)	(3)	(4)
Ln(exchange rate) × relation specificity§	1.828	2.214	2.634	2.751
	[1.445]	[1.855]	[1.813]	[1.714]
Ln(exchange rate) × R&D intensity§		0.001	-0.003	0.002
		[0.015]	[0.016]	[0.016]
Ln(exchange rate) × elasticity of substitution§		3.735	-5.700	-3.192
		[17.463]	[17.640]	[17.110]
Ln(exchange rate)	-0.494	-0.503	-0.128	-0.327
	[0.940]	[1.158]	[1.140]	[1.068]
GDP		2.437***	4.119***	3.363***
		[0.781]	[0.859]	[0.812]
PPI		0.066	-0.038	0.159
		[0.356]	[0.378]	[0.346]
Market share			-0.034	-0.039
			[0.031]	[0.030]
Ln(exchange rate) × market share			1.494***	1.345***
			[0.088]	[0.086]
Firm rank				-1.328***
				[0.098]
Ln(exchange rate) × firm rank				0.041
				[0.034]
Observations	48,399	36,512	36,512	36,512

Notes: Firm-product-country fixed effects and year fixed effects are included. Cluster-robust standard errors in brackets. Clustering is at the country-year level. § These three variables are included only as interaction terms because their own variations are absorbed by the fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

4.2 Robustness Checks

We conduct three robustness checks in this subsection.[15] First of all, since the products that use type-x Chinese inputs and those use type-o Chinese inputs might have different ϕ's, an empirical concern arises as to whether the different patterns shown by ϕ-related coefficients under the two types are driven by the differences in ϕ-values rather than different adjustment patterns between the two types. To address this concern, we match exporters under type-o with their peers under type x using the average ϕ of the latter. That is, under type x, we compute the mean $\bar{\phi}^x_{dt}$ and the standard deviation σ^x_{dt} of the ϕ-values in each destination-year (dt) duplet. Then, we construct a

[15]In the working paper version of this paper, we discussed various other robustness checks, accounting for different exchange-rate regimes, product scopes, and destination types. To save space, those results are not reported here but are available upon request.

Table 3: Trading Prices and Quantity (Type o, Hypothesis 1)

	Hypothesis 1a				*Hypothesis 1b*			
	Dependent variable: ln(price)				Dependent variable: ln(quantity)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(exchange rate)×relation specificity§	-0.274	-0.113	-0.109	-0.107	0.767*	1.204**	1.421*	1.320**
	[0.172]	[0.245]	[0.245]	[0.243]	[0.440]	[0.574]	[0.752]	[0.628]
Ln(exchange rate)×R&D intensity§		-4.398***	-4.204***	-4.099***		8.175**	14.559***	8.105*
		[1.569]	[1.563]	[1.557]		[4.093]	[4.901]	[4.387]
Ln(exchange rate)×elasticity of substitution§		-0.000	-0.000	-0.000		0.005	0.007**	0.006*
		[0.001]	[0.001]	[0.001]		[0.003]	[0.003]	[0.003]
Ln(exchange rate)	0.378***	0.381**	0.404***	0.399***	-0.030	-0.253	0.518	0.768*
	[0.109]	[0.149]	[0.150]	[0.148]	[0.290]	[0.362]	[0.478]	[0.397]
GDP		0.162**	0.221***	0.214**		1.326***	3.266***	3.835***
		[0.082]	[0.083]	[0.084]		[0.246]	[0.275]	[0.325]
PPI		0.107***	0.127***	0.128***		-0.135	0.560***	0.478***
		[0.041]	[0.040]	[0.040]		[0.101]	[0.109]	[0.106]
Market share			0.060***	0.060***			2.085***	2.126***
			[0.011]	[0.011]			[0.038]	[0.038]
Ln(exchange rate) × market share			-0.003	-0.003			0.000	-0.003
			[0.003]	[0.003]			[0.009]	[0.009]
Firm rank				0.000				-0.000***
				[0.000]				[0.000]
Ln(exchange rate) × firm rank				0.000				0.000**
				[0.000]				[0.000]
Observations	3,688,078	2,709,427	2,709,427	2,709,427	3,688,078	2,709,427	2,709,427	2,709,427

Notes: Firm-product-country fixed effects and year fixed effects are included. Cluster-robust standard errors in brackets. Clustering is at the country-year level. § These three variables are included only as interaction terms because their own variations are absorbed by the fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

set of exporters $\{i'dt\}$ under type o whose cross-product average ϕ, denoted by $\bar{\phi}^{o}_{i'dt}$, satisfy

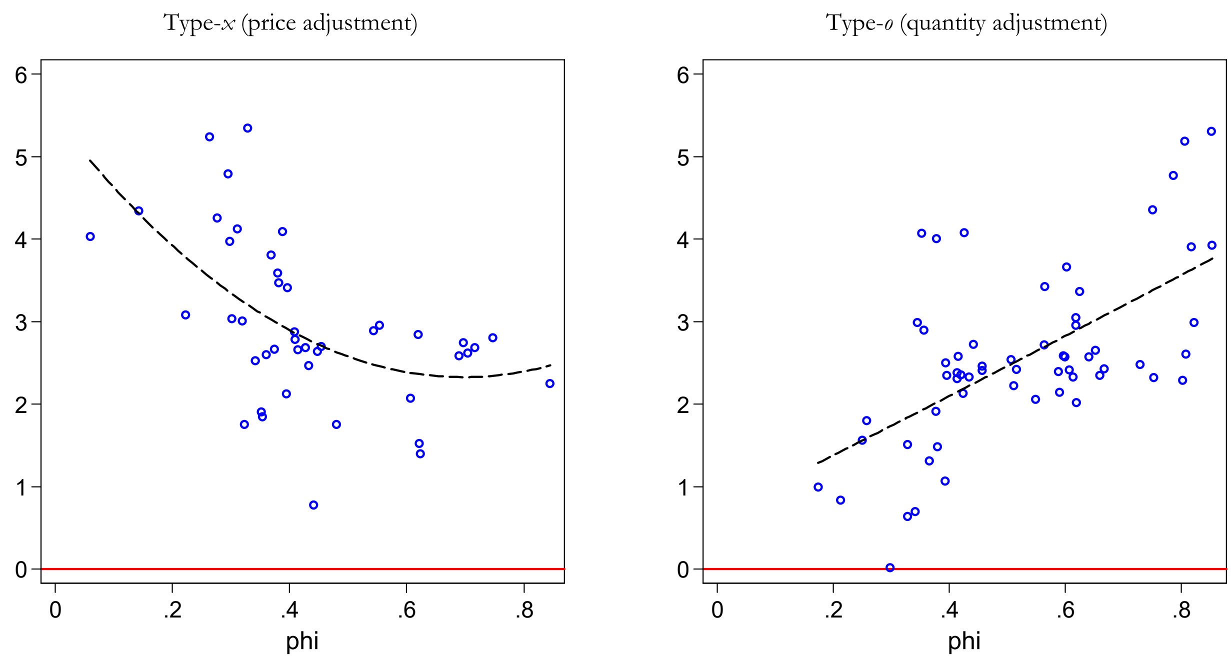
$$\bar{\phi}^{x}_{dt} - k\sigma^{x}_{dt} < \bar{\phi}^{o}_{i'dt} < \bar{\phi}^{x}_{dt} + k\sigma^{x}_{dt}.$$

The constant $k = 1$ to 3 determines the size of the set: the larger k is, the more exporters fall into the set. Such sets, as subsamples, represent the firms under type o that have average relation-specificity comparable with exporters under type x. Panel A of **Table 4** compares matched subsamples with the unmatched (full) sample. Subsample size rises as k rises from 1 to 3, though the average ϕ barely changes at the same time. We run regression (16) using matched subsamples and report the results in Panel B of the table. Previous findings continue to hold.[16] The robustness to

[16]Some of the coefficients are not significantly different from zero, though the corresponding total effects $\hat{\lambda} + \hat{\delta}\phi$, given $\phi > 0$, are still in support of the corresponding hypotheses.

Figure 2: Price Adjustment, Quantity Adjustment, and Relation-specificity

Notes: The left panel is for type-x inputs, which plots price adjustments (in response to exchange rate fluctuations) against relation-specificity (Nunn's measure). The right panel is for type-o inputs, which plots quantity adjustments against relation-specificity. In both panels, each dot represents a HS4 category, the unit of adjustments is percentage point, and the dashed curves represent quadratic predictions.



the use of matched sample indicates that the previous findings were not driven by the differences in ϕ-values between the two types.

The second robustness check makes use of the entire sample composed by both types. The previous Tables 1 to 3 apply difference-in-differences to the two types of Chinese exporters separately. We now pool them together and use a triple-difference estimation to test whether price and quantity adjustments differ between the two types. Recall that the yuan price's elasticity with respect to exchange rate is unrelated to ϕ under type o but is decreasing in ϕ under type x. So, if we add a triple-interaction term between exchange rate, relation-specificity ϕ, and a dummy variable that equals 1 if the exports are of type-x, the coefficient of the triple-interaction term should be negative. Similarly, as for quantity, the coefficient of the triple-interaction term should also be negative, because the quantity's elasticity with respect to exchange rate is zero under type x but is increasing in ϕ under type o.

The triple-difference estimates are reported in **Table 5**. Columns (1)-(2) are for price, and columns (3)-(4) for quantity. Columns (2) and (4) show the major findings, interacting the type-x dummy with log exchange rate itself and the previous two-way interaction (i.e. between exchange rate and relation-specificity). Columns (1) and (3), as a comparison, do not include the triple-difference related terms. The results are in line with the reasoning above.

Table 4: Robustness I
Matched Sample (Subsample of Type o Matched to Corresponding Type x)

Panel A: Statistics

	Mean	S.D.	No. of obs.	No. of firms
Unmatched:	0.62	0.17	3,689,189	61,241
Matched:				
k=1	0.63	0.15	1,543,930	27,290
k=2	0.63	0.15	2,278,532	37,712
k=3	0.63	0.15	2,665,867	44,589

Panel B: Results

	k=1		k=2		k=3	
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(price)	ln(quantity)	ln(price)	ln(quantity)	ln(price)	ln(quantity)
Ln(exchange rate)	-0.312	4.103**	-0.239	3.836***	-0.176	3.593***
× relation specificity	[0.580]	[1.630]	[0.383]	[1.180]	[0.329]	[0.983]
Ln(exchange rate)	0.862**	-0.858	0.650***	-0.679	0.557***	-0.553
	[0.371]	[0.997]	[0.245]	[0.722]	[0.209]	[0.609]
Observations	1,267,968	1,267,968	1,831,606	1,831,606	2,100,326	2,100,326

Notes: Firm-product-country fixed effects and year fixed effects are included. Cluster-robust standard errors in brackets. Control variables include all those in columns (4) and (8) of Table 3. *** p<0.01, ** p<0.05.

The third robustness check is related to the direction of the exchange rate change. The previous hypotheses do not rely on the direction of the exchange rate change. In our sample, 79.5 percent of the country-year pairs are associated with the yuan's depreciation (essentially, the depreciation of the US dollar) rather than its appreciation. In **Table 6**, we divide the sample between the two directions of exchange-rate change and rerun our earlier regressions using each subsample. Columns (1)-(2) are concerned with the price adjustments under type x, while columns (3)-(4) are concerned with the quantity adjustments under type o. The implications of our model, as stated in Hypotheses 1 and 2, turn out to hold in both directions.

5 Concluding Remarks

We find that Chinese exporters, in response to exchange-rate fluctuations, adjust their price margins if they make relation-specific inputs for foreign producers, but adjust both price and quantity margins if they make non-relation-specific inputs. Further, the price adjustments for relation-

Table 5: Robustness II
Diff-in-diff-in-diff Results

	(1)	(2)	(3)	(4)
Dep. Variable	ln(price)		ln(quantity)	
Ln(exchange rate)	0.675**	0.669**	-0.765	-0.754
	[0.268]	[0.267]	[0.466]	[0.467]
Ln(exchange rate) × relation specificity	-0.175	-0.167	0.407	0.390
	[0.389]	[0.387]	[0.696]	[0.698]
Type-x dummy	0.332***	0.334***	0.997***	0.992***
	[0.039]	[0.039]	[0.026]	[0.028]
Ln(exchange rate) × Type-x dummy		0.054**		0.092*
		[0.021]		[0.048]
Ln(exchange rate) × relation specificity × Type-x dummy		-0.093***		-0.137*
		[0.033]		[0.073]
Observations	1,092,162	1,092,162	1,092,162	1,092,162

Notes: Firm-product-country fixed effects and year fixed effects are included. Cluster-robust standard errors in brackets. Control variables include all those in columns (4) and (8) of Table 3. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Robustness III
Directions of Exchange-Rate Fluctuations

	(1)	(2)	(3)	(4)
Type of inputs	x	x	o	o
Dep. Variable	ln(price)	ln(price)	ln(quantity)	ln(quantity)
Direction of exchange rate	Yuan Depreciatio	Yuan Appreciation	Yuan Depreciation	Yuan Appreciation
Ln(exchange rate)	0.104***	0.366***	0.175***	0.267***
	[0.022]	[0.080]	[0.009]	[0.075]
Ln(exchange rate) × relation specificity	-0.106***	-0.604***	0.292***	0.463***
	[0.033]	[0.161]	[0.015]	[0.125]
Observations	37,632	10,767	2,457,611	1,230,467

Notes: Firm-product-country fixed effects and year fixed effects are included. Cluster-robust standard errors in brackets. Control variables include all those in columns (4) and (8) of Table 3. *** p<0.01.

specific inputs and the quantity adjustments for non-relation-specific inputs are smaller in magnitude if the inputs are intensively used in foreign production. These patterns can be well-explained when incomplete contracting and incomplete passthrough are combined in analysis.

This is a microeconomic study, though it may help to address a macroeconomic puzzle — why global trade volumes show declining responses to exchange-rate fluctuations. Relation-specific transactions are now estimated to account for more than half of global trade volumes, though they are usually not reported by customs separately. As shown in this paper, the quantity margins of relation-specific inputs are far more rigid than those of non-relation-specific inputs, and the sensitivity of price margins are negatively associated with relation-specificity. In this regard, relation-specificity helps stabilize both prices and quantities in global trade.

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Table A1: Descriptive Statistics

	Mean	S.D.	Mean	S.D.
Panel A: Customs data				
	Type *x*		Type *o*	
For an average firm-product-destination-year (thousand yuan):				
Value	1675.673	7837.625	309.97	2191.1
Price	25.396	1999.988	1.59	52.74
A single firm				
Number of products:	2.65	4.18	26.79	74.39
Number of destination countries:	4.46	6.82	8.53	11.14
Number of destination continents:	1.76	1.13	2.37	1.42
Total number of				
Firms	4671		61241	
Products	2117		6863	
Destination countries	85		85	
Year	6		6	
Firm-product	12376		1615707	
Firm-product-destination country-year (sample size)	48399		3689189	
Panel B: Macro data (country-year level)				
Change rate of real exchange rate: [-0.31,0.32]			0.04	0.08
Change rate of GDP: [-0.41,0.46]			0.04	0.05
Panel C: Industrial data (product level)				
Relation specificity (Nunn) [0.03,0.99]			0.50	0.23
R&D intensity [0.00,0.09]			0.02	0.02